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# ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

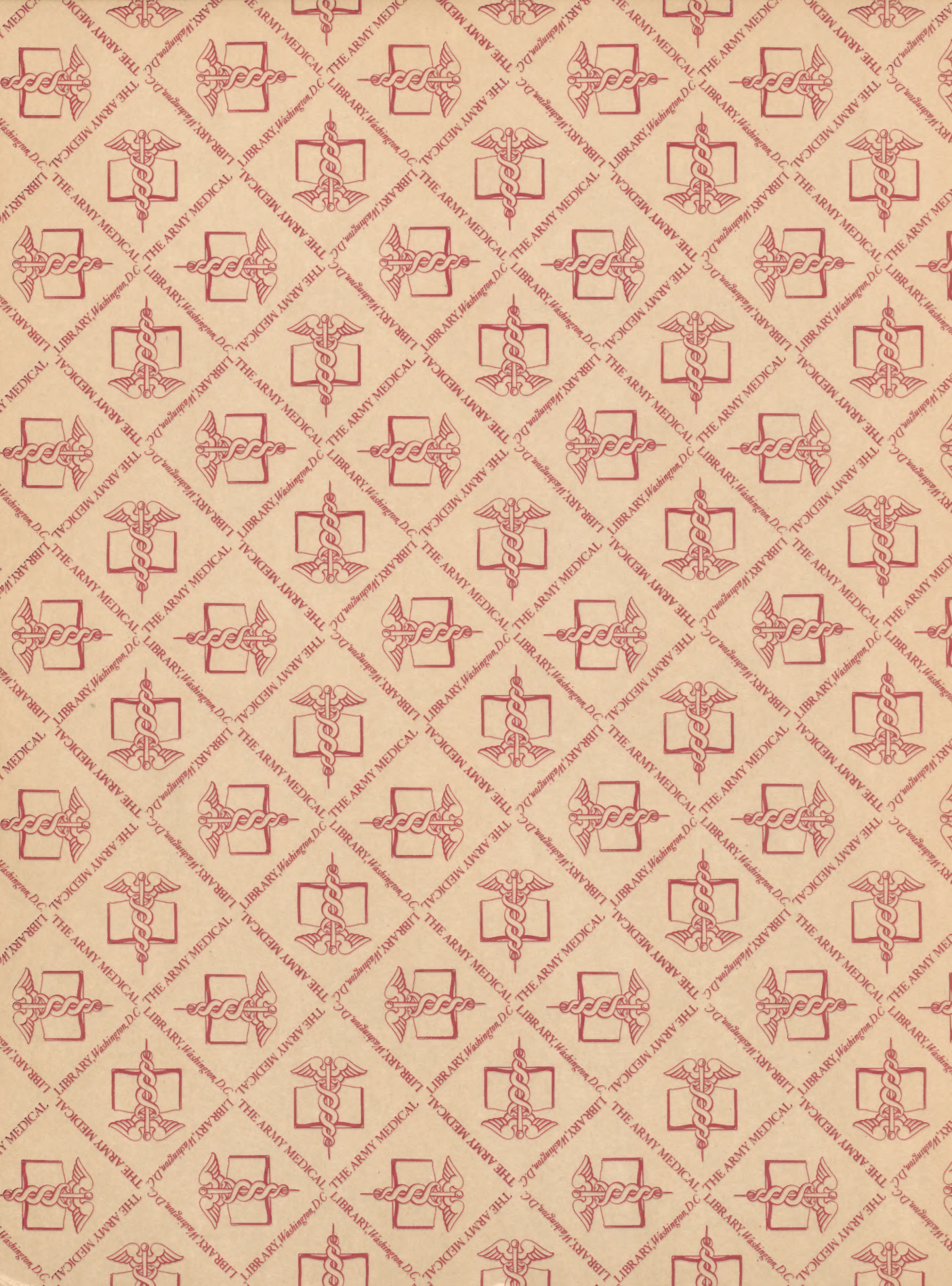
PROJECT NO. P-51 - MANUAL TRAVERSING EFFORT IN TANKS

Project No. P-51

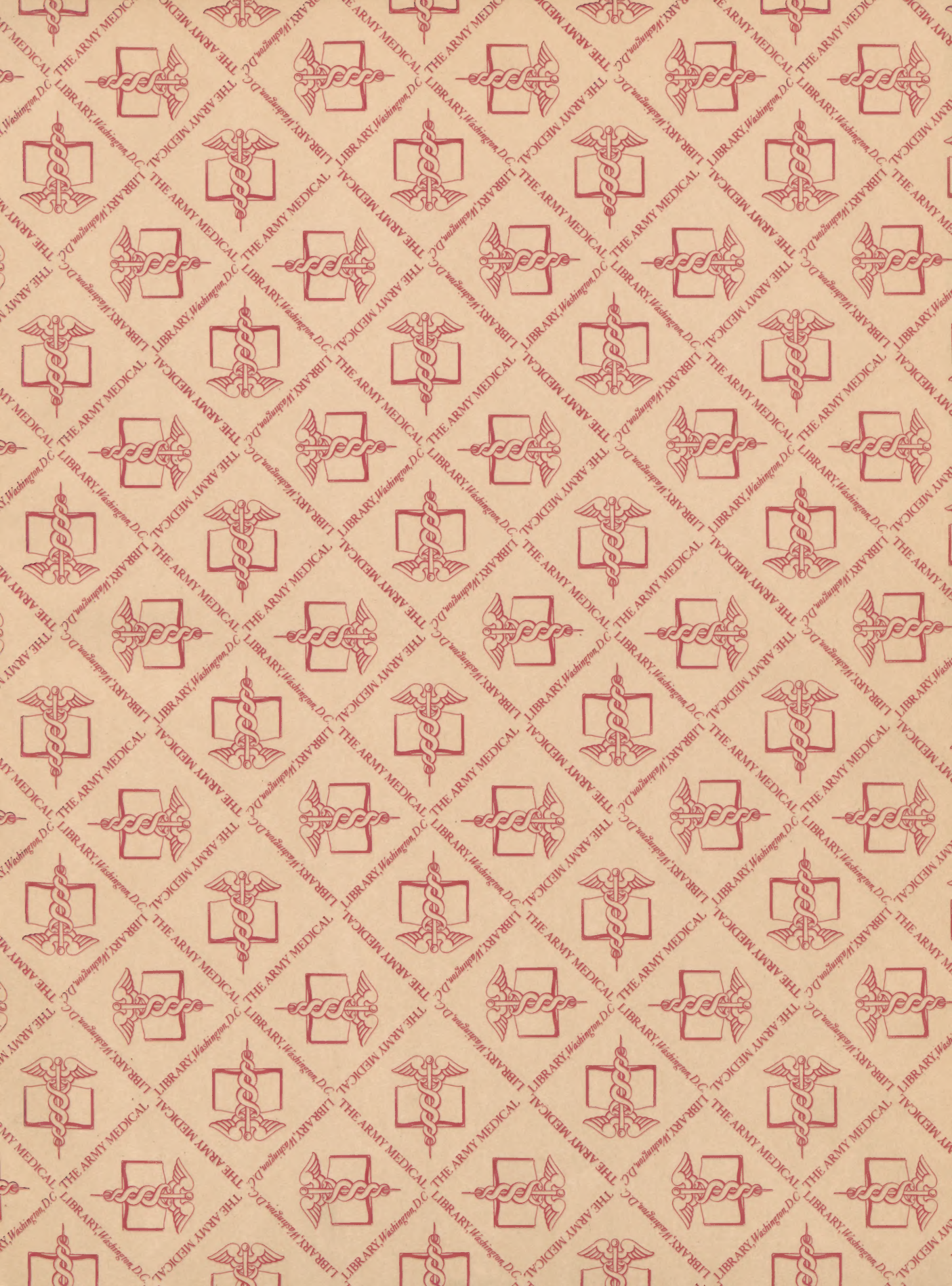
ARMY  
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10 October 1945



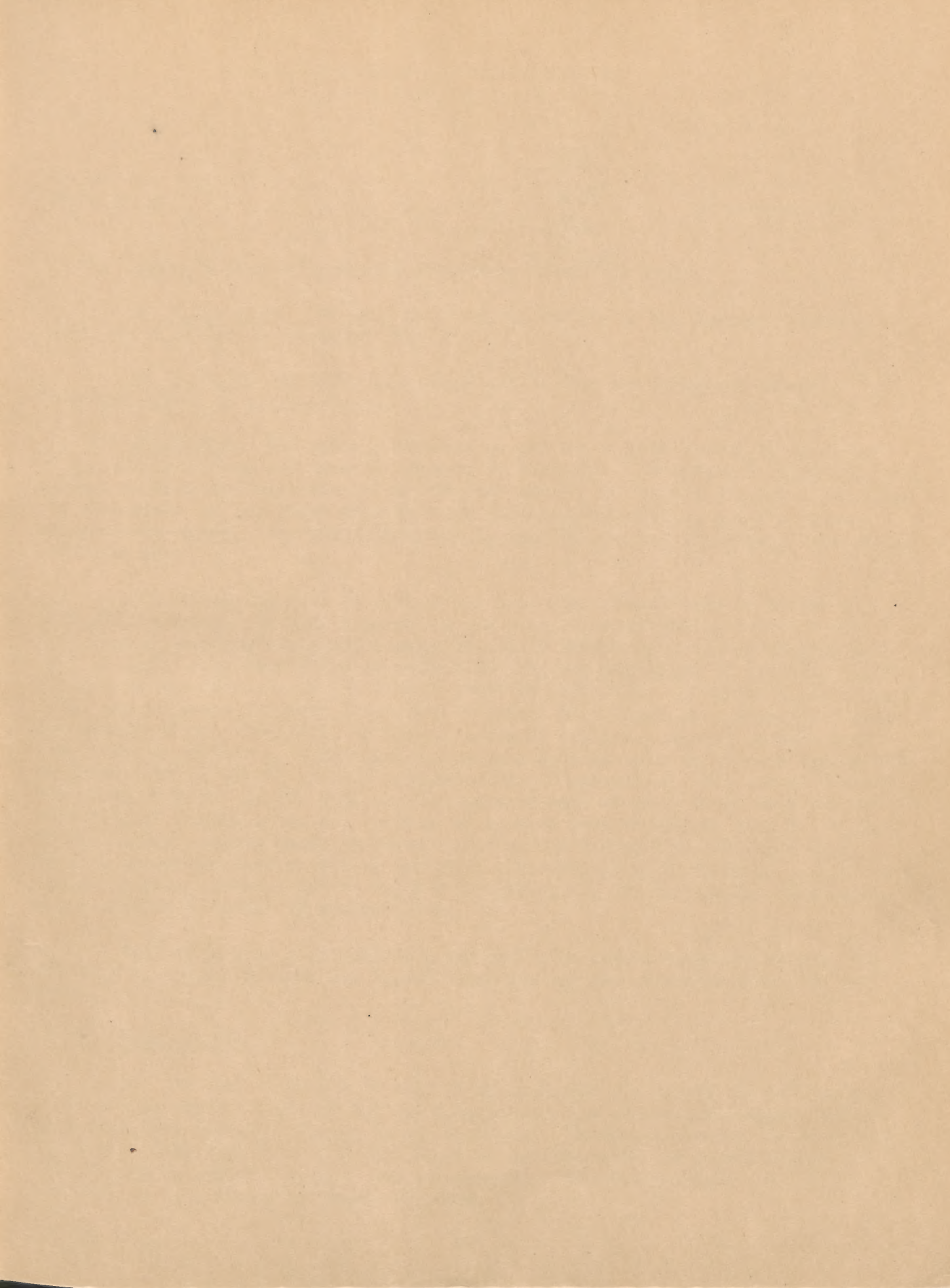














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ARMORED MEDICAL RESEARCH LABORATORY  
Fort Knox, Kentucky

Project No. P-51  
SPMEA 470.8

10 October 1945

1. PROJECT: NO. P-51, Manual Traversing Effort in Tanks.

a. Authority: 1st Memo Indorsement, Office of The Surgeon General, SPMDO 470.8, dated 11 December 1944.

b. Purpose: To determine magnitude of factors affecting manual traverse effort in current tanks.

2. DISCUSSION: The manual traverse is the means most generally used to adjust the main tank gun onto the target in azimuth. Conventional power traverse is not sufficiently accurate to do the task and it is therefore general practice for the gunner to use power traverse for scanning, searching, and for gross angular adjustment. For final accurate laying the control is switched and manual traverse used.

The manual traverse is one of the last connecting links in delivering fire to the enemy. So much depends on its having proper characteristics and performance that the using arm cannot afford to accept unnecessary compromise. Much is left to be desired in the complete traverse mechanism of existing tanks as well as specifically in the manual traverse mechanism. Of prime importance until and if power traverse is capable of micro adjustment is a means for rapid convenient switch from power to manual traverse control. Manual control backlash must be reduced to a minimum; the manual control must be of such design and so located as to permit natural unimpeded smooth operation. The manual control must have "feel". Turret friction and balance must be such as to keep the "feel" essentially uniform under the variety of aspects from which the tank is employed. As precaution against power traverse failure, the manual traverse must not require excessive turning effort and must have optimum gear ratio to permit the gunner to scan, search, and be capable of laying the gun on targets requiring gross angular movement in minimum time.

This report is particularly concerned with turret traverse effort, its relation to turret balance and turret friction and the possible effect on gun laying accuracy.

3. CONCLUSIONS:

a. The data obtained in this study indicate the degree of influence certain tank characteristics have on manual traverse effort and suggest the influence they may have on gun laying accuracy. These data should be of interest and use to tank designers and tank users in establishing the capabilities and limitations of manual traverse and consequently the need for more general use and further development of power traverse.

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b. The impossibility of rating or specifying manual traverse characteristics on the basis of an unqualified single figure is clearly shown.

c. It is evident that if manual traverse is to be used for other than fine laying or leisure scanning that the turning effort should not exceed five pounds under the most severe tilt conditions which may be expected to be encountered. Meeting such requirements will require much better turret balance than now generally exists.

d. Many manual traverse characteristics can be adequately specified in terms of the type of curves presented in this report. The apparatus developed offers a simple tool for evaluation and checking.

e. Concise military requirements for manual traverse are needed before basic specifications for optimum equipment can be established. Considerations are: (1) Will manual traverse be required to perform all traverse duties?

- (a) accurate laying
- (b) tracking (rate?)
- (c) rapid traverse through wide azimuths
- (d) use for extended periods
- (e) use on level only or tilted (if so how much)

(2) Will manual traverse be used only for accurate laying?

- (a) if so, gear ratio might well be increased

(3) Will manual traverse be stand-by for a power traverse meeting all general requirements?

- (a) if so, what general requirements of (1) above can be reduced?

f. The data presented will have application to power traverse design.

g. Excessive turret friction was not indicated for tanks tested.

#### 4. RECOMMENDATIONS:

a. That data herein presented be considered in establishing requirements for manual traverse equipment for future tanks.

b. That effort be made to better balance turrets, reduce back lash in manual traverse equipment, provide more convenient faster method of shifting from power to manual traverse, improve power traverse for micro adjustment, eliminate spade grip or reduce squeeze required to operate it.

c. That not over five pounds manual traverse effort under most severe conditions of tilt to be encountered be established for vehicles not equipped with power traverse.







d. That not over 10 pounds manual traverse effort for most severe tilt conditions to be encountered with maximum of 5 pounds on level be established for vehicles equipped with power traverse.

e. That production tests be set up to assure reasonable uniformity in manual traverse effort of like tanks.

NOTE: The recommendations as set forth in this project have been concurred in by Colonel Louis V. Hightower, President, Army Ground Forces Board No. 2.

Submitted by:

Lester B. Roberts, Major, SnC

Wendell E. Mann, Captain, MAC

Clifford G. Riker, T Sgt

APPROVED William B. Bean  
WILLIAM B. BEAN  
Major, Medical Corps  
Commanding

2 Incls.

#1 - Appendix

#2 - Figures 1 thru 18







## APPENDIX

### I PROCEDURE:

Equipment for measuring and recording manual traverse effort was designed and constructed for this study. The equipment consists of (1) a modified conventional handwheel assembly, (2) a D.C. amplifier and (3) direct inking recorder. The equipment is shown in Figure 9. Figure 18 shows schematic wiring diagram. The handwheel assembly carries a crank arm on which is mounted two SR-4 strain gages which are the active elements for measuring pressure exerted on the handle. A commutator in the body of the assembly serves to connect the gages to the rest of the circuit.

Figure 10 shows the assembly mounted in a tank.

Figure 11 shows typical curves obtained with the equipment. The data are replotted for various tanks in Figures 1 to 8.

The manual traverse effort was determined with the equipment described above by measuring the tangential pull or push required to rotate the handwheel during operation. The results were given in pounds and may be converted to inch pounds torque by multiplying by 3.6 inches, the radius of the handwheel.

Calibration was made by locking the turret and applying pull on the handwheel with a calibrated spring scale. The gain of the amplifier was adjusted to give appropriate deflection of the recorder.

All test runs were made by a single experienced operator. Each test run consisted of traversing the turret clockwise and counter-clockwise through  $360^\circ$ .

Two speeds of traverse were used, approximately  $65^\circ$  per minute (54 turns of the handwheel per minute for M4 and T26 tanks and 47 turns for M24 tanks) and  $200^\circ$  per minute (164 turns of the handwheel per minute for M4 and T26 tanks and 146 turns for M24 tanks.) The rate of traverse was maintained as near constant as possible. A rest period was allowed the operator between runs.

Runs were made with each tank on the level and at angular tilts in steps up to about 13 degrees. The tank was tilted by raising one track on cross-ties as shown in Figure 16. The angle of tilt was measured with a gunner's quadrant set on a smooth surface of the turret top.

Series of runs were made on two M4 tanks with 75 mm gun, one M4 with 76 mm gun, one M4 with 105 mm Howitzer, two M24 tanks and two T26 tanks.





## II RESULTS:

A study of the manual traverse figures shows that manual traverse turning effort is not a fixed value but is a variable quantity influenced by many factors.

The curve's width shows that turning effort varies between limits increasing with the absolute value of the turning effort and the speed of turning. It is a measure of the smoothness of traverse which is influenced by play in the gear train, back lash, uniformity of friction, placement of control and operator control. For following a moving target it is obvious that this curve width should be minimal. In the tests the experienced operator attempted to operate the handwheel as smoothly as possible.

The change in the turning effort curves with increase tank tilt shows the effect of turret imbalance and quantitatively measures the common practical difficulty of traversing the turret when the tank is on a slope. It shows the reason why at certain azimuths, with the tank on a slope, laying the gun on a target is relatively easy and at other azimuths very difficult. It will be noted that where the right traverse curve intersects the left the effort to traverse in either direction is minimal. Where the two curves are far apart a large pull is required for turning in one direction and a correspondingly large holding back required when the direction is reversed. Again it should be obvious that for accuracy of laying the deviation of the curves from one another should be as small as possible. This requires good turret balance. A further study to evaluate this effect is needed.

## III PHYSIOLOGICAL CONSIDERATIONS:

The operator experienced little difficulty in traversing the turret of any of the tanks at slow speed when the tank was on the level. It was possible to traverse the turret for extended periods under these conditions. At fast speed under the same conditions difficulty was experienced in keeping the eye to the periscope. Tremor set in after traversing about  $180^{\circ}$  and it was generally impossible to continue at fast speed beyond about  $550^{\circ}$  traverse.

On the tilts it was increasingly difficult to pull the turret "up hill" or hold it back going "down hill". At  $10^{\circ}$  tilt it was necessary to remove eye from periscope, in some cases change to braced position and to use both hands or change from one hand to the other in order to complete  $360^{\circ}$  at fast speed.

So long as the effort required remained under approximately five pounds and was reasonably uniform (tank level) the turret could be traversed for about 15 minutes at slow speeds, for approximately five minutes at moderate speed and generally less than three minutes at fast speed.







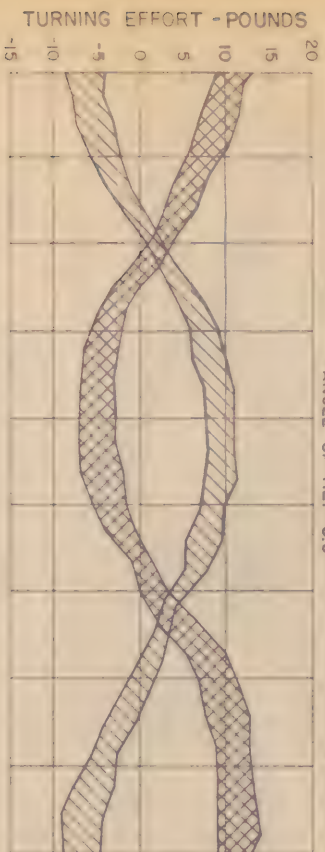
# MANUAL TRAVERSE TURNING EFFORT M4 TANK 75 MM GUN

SLOW SPEED

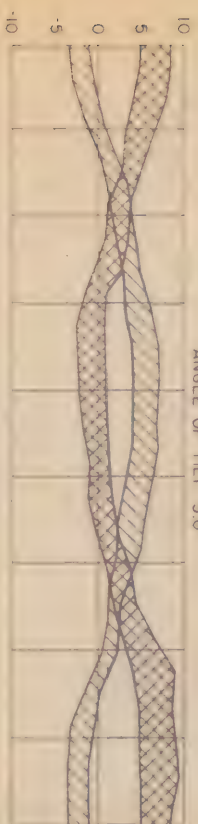
ANGLE OF TILT 13° (RIGHT SIDE TANK RAISED)



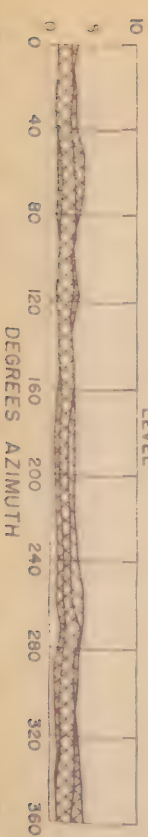
ANGLE OF TILT 8.5°



ANGLE OF TILT 5.0°

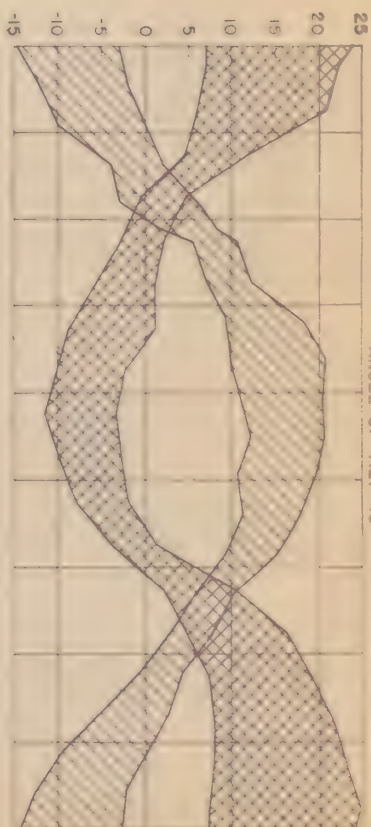


LEVEL

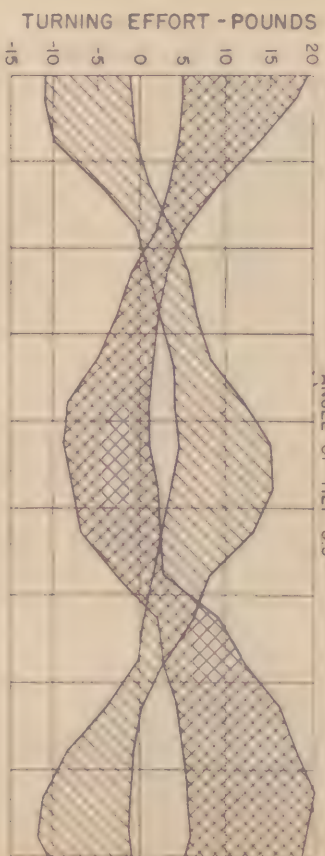


FAST SPEED

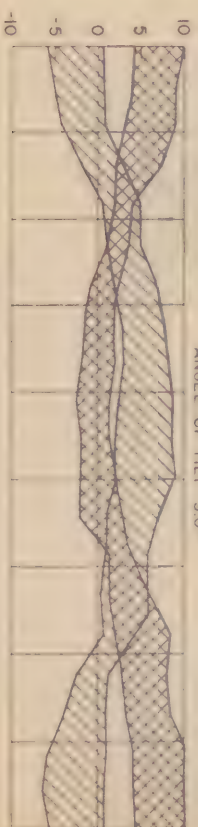
ANGLE OF TILT 13°



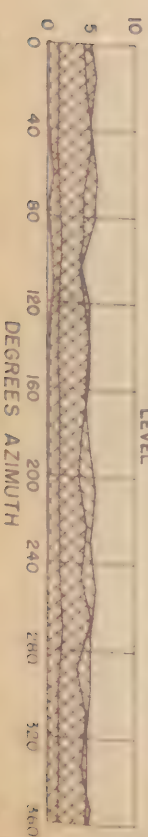
ANGLE OF TILT 8.5°



ANGLE OF TILT 5.0°



LEVEL

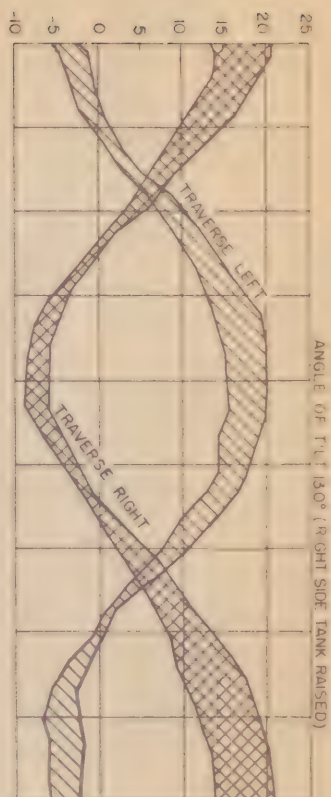




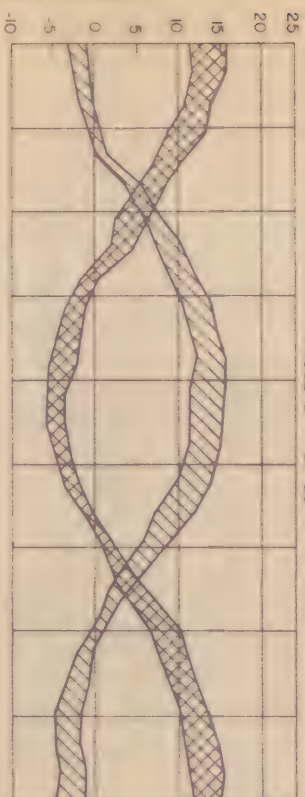


# MANUAL TRAVERSE TURNING EFFORT M4 TANK 75 MM GUN

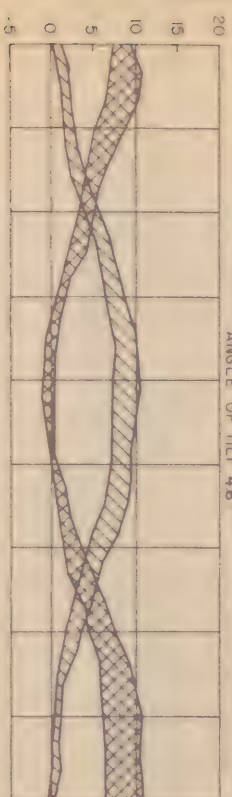
SLOW SPEED



ANGLE OF TILT 95°



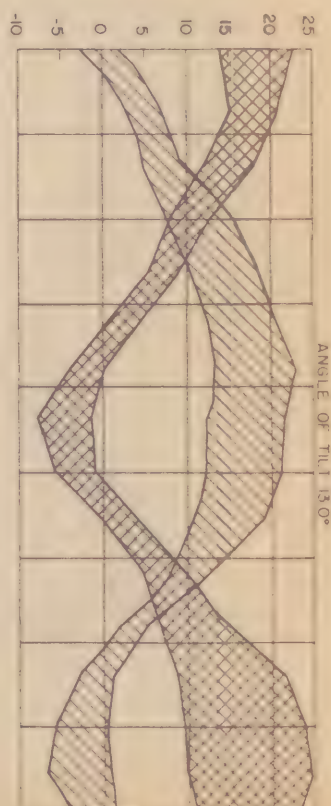
ANGLE OF TILT 46°



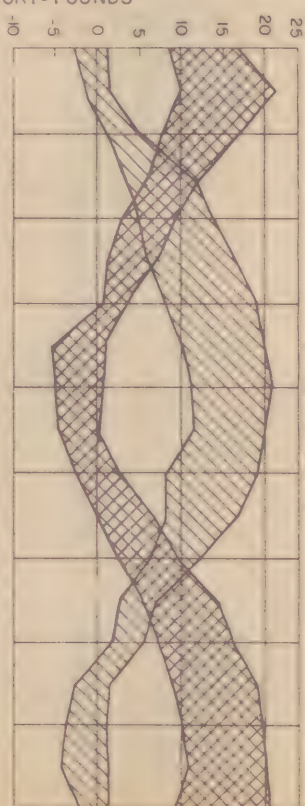
LEVEL



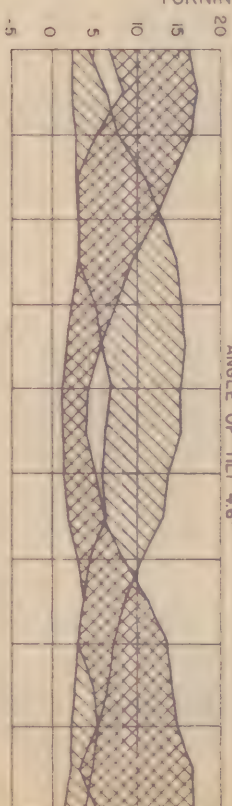
FAST SPEED



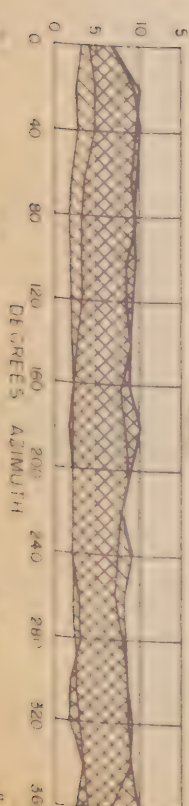
ANGLE OF TILT 95°



ANGLE OF TILT 46°



LEVEL



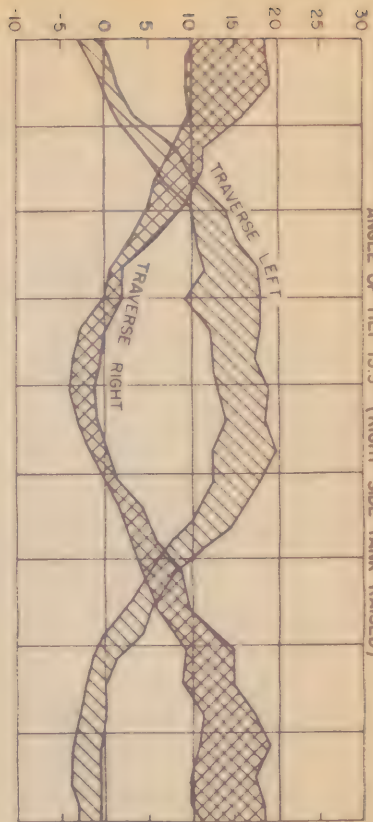




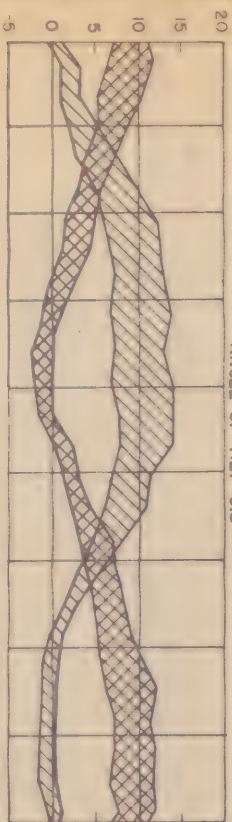
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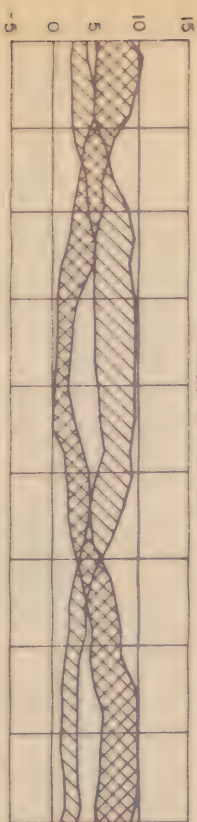
ANGLE OF TILT 13.5° (RIGHT SIDE TANK RAISED)



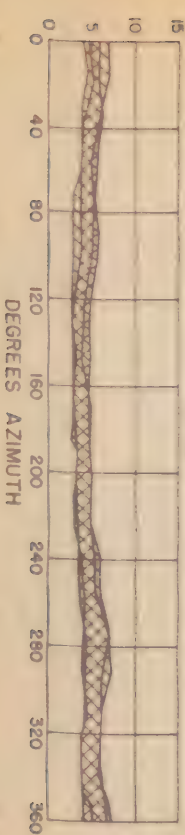
ANGLE OF TILT 9.2°



ANGLE OF TILT 4.6°

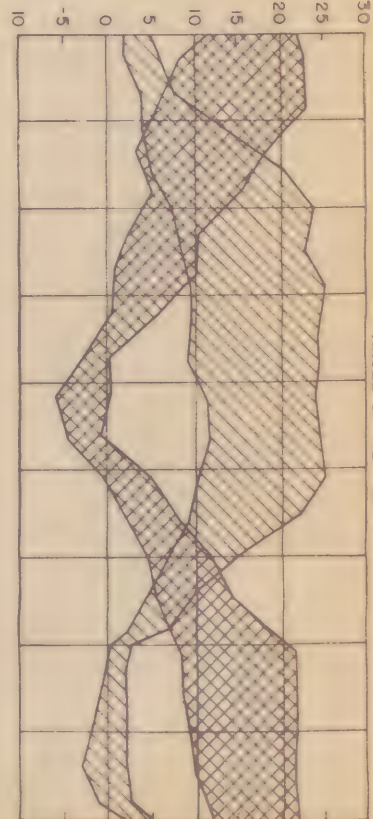


LEVEL

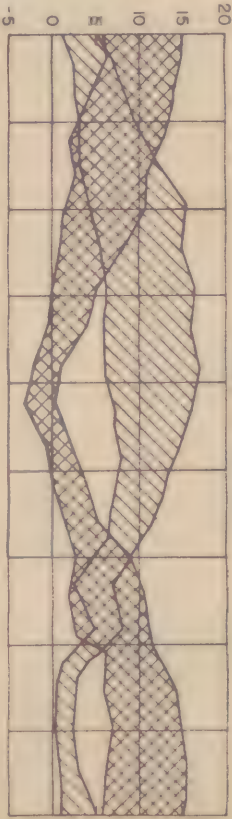


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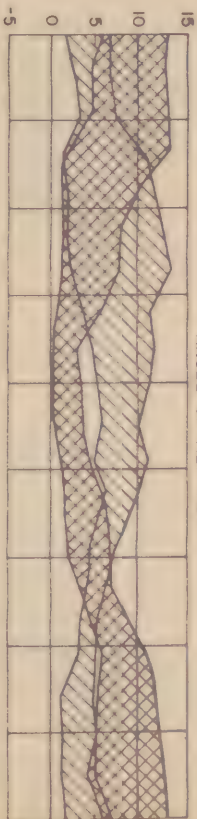
ANGLE OF TILT 13.5°



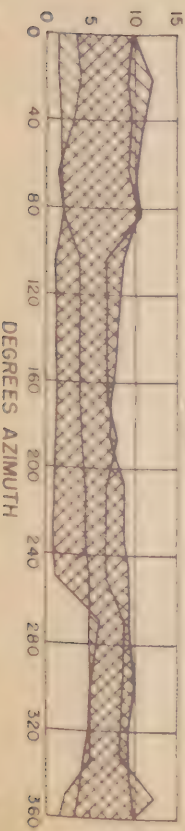
ANGLE OF TILT 9.2°



ANGLE OF TILT 4.6°



LEVEL



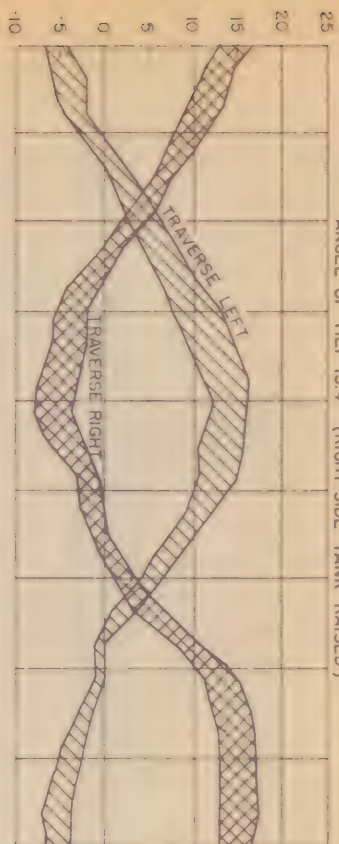




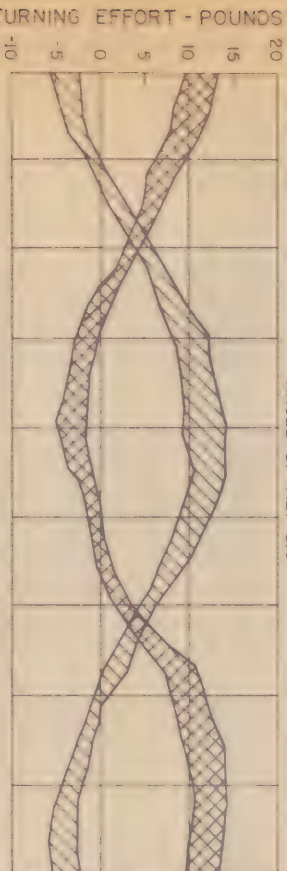
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SLOW SPEED

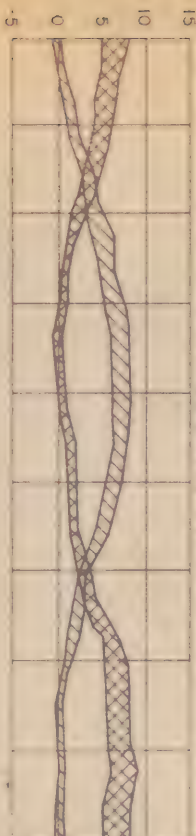
ANGLE OF TILT 13.4° (RIGHT SIDE TANK RAISED)



ANGLE OF TILT 9.5°



ANGLE OF TILT 4.7°

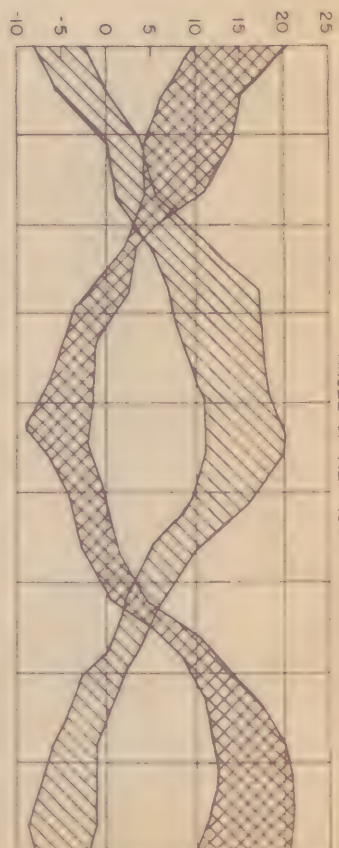


LEVEL

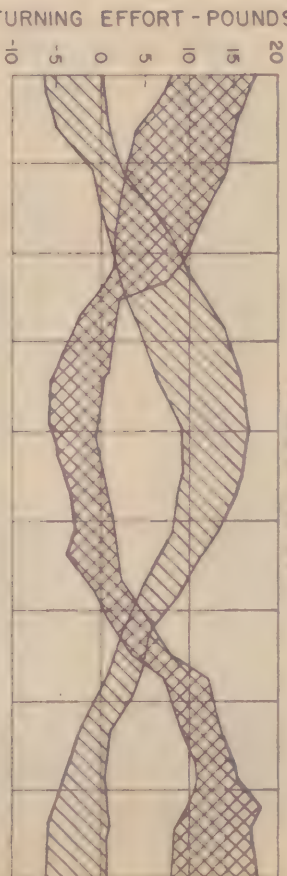


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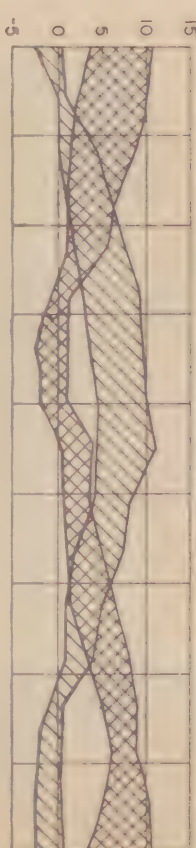
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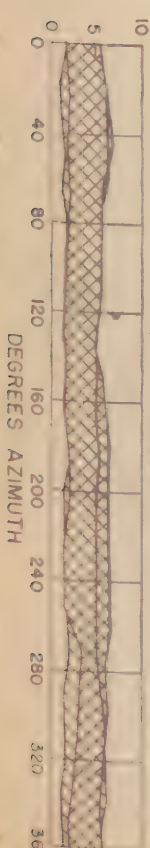
ANGLE OF TILT 9.5°



ANGLE OF TILT 4.7°



LEVEL



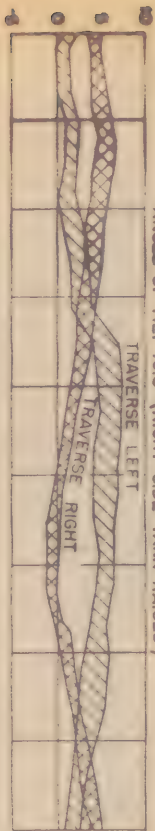




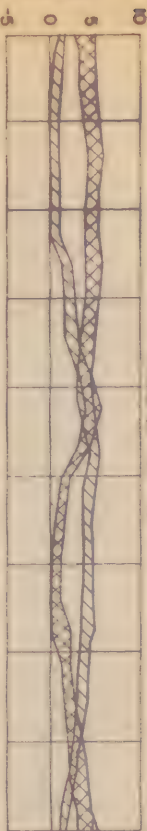
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SLOW SPEED

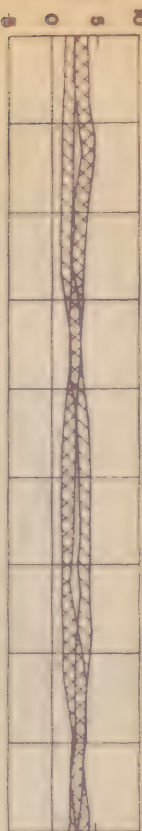
ANGLE OF TILT 10.8° (RIGHT SIDE TANK RAISED)



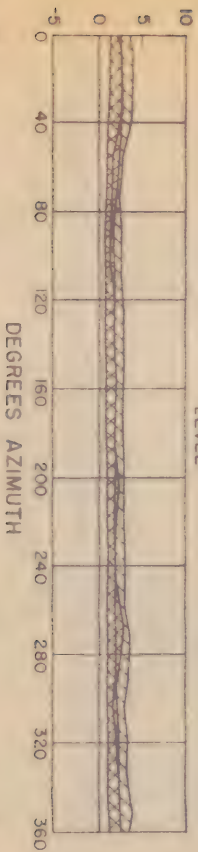
ANGLE OF TILT 7.3°



ANGLE OF TILT 3.8°

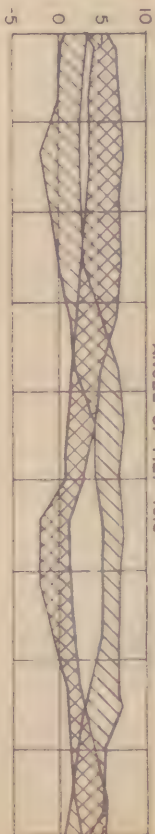


LEVEL

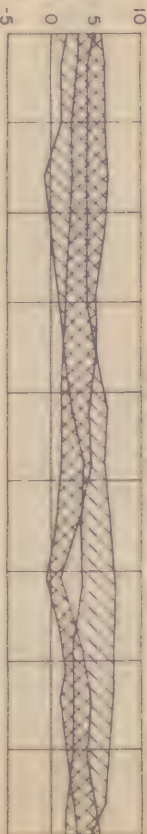


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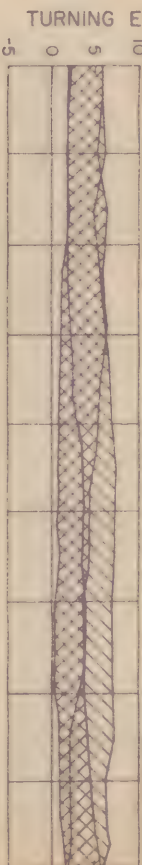
ANGLE OF TILT 10.8°



ANGLE OF TILT 7.3°



ANGLE OF TILT 3.8°



LEVEL

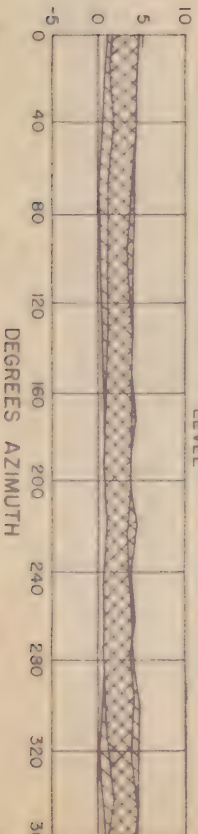


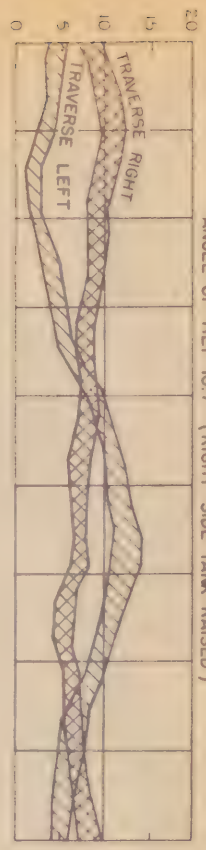
FIGURE 5



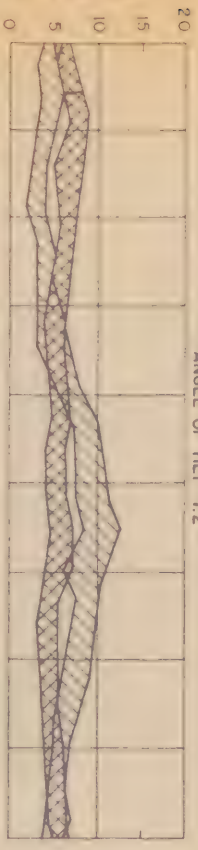


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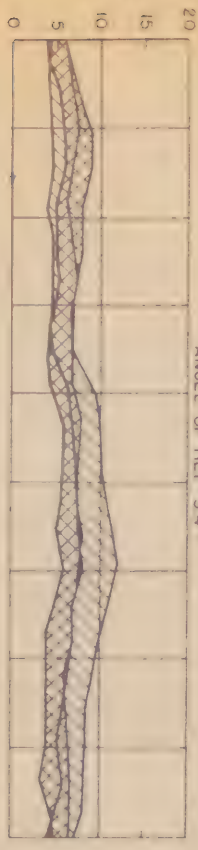
SLOW SPEED  
ANGLE OF TILT 10.7° (RIGHT SIDE TANK RAISED)



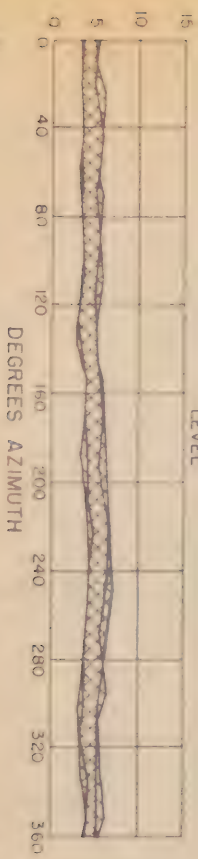
ANGLE OF TILT 7.2°



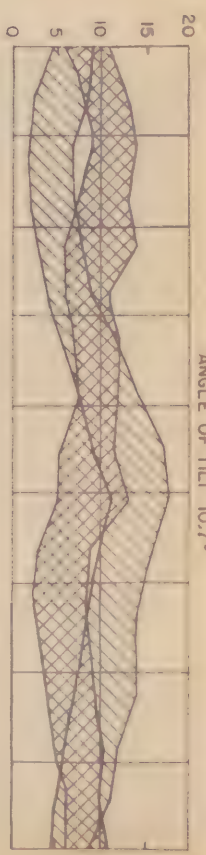
ANGLE OF TILT 3.4°



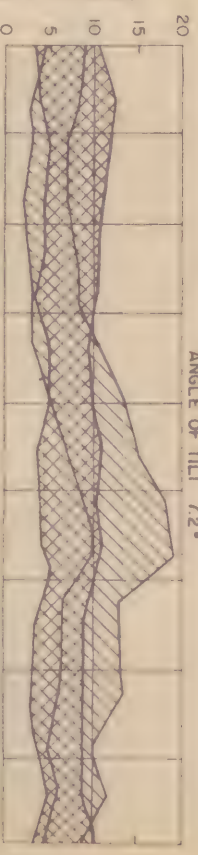
LEVEL



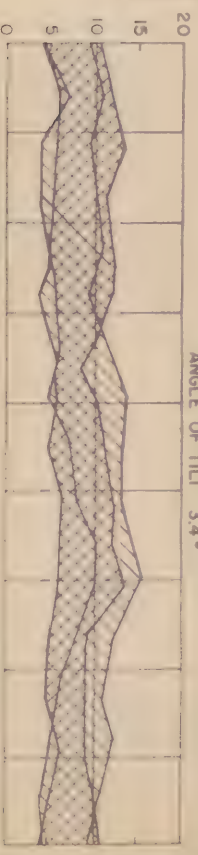
FAST SPEED  
ANGLE OF TILT 10.7°



ANGLE OF TILT 7.2°



ANGLE OF TILT 3.4°



LEVEL

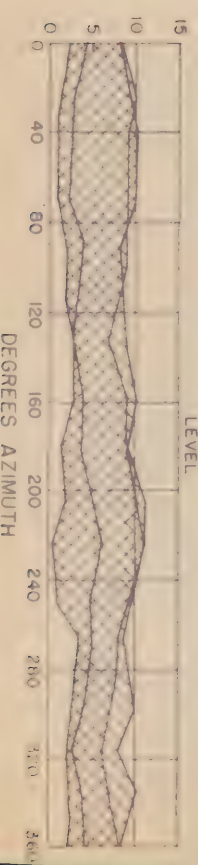


FIGURE 6

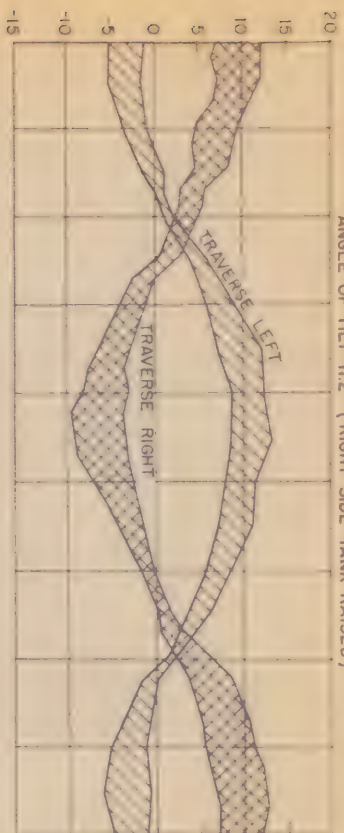




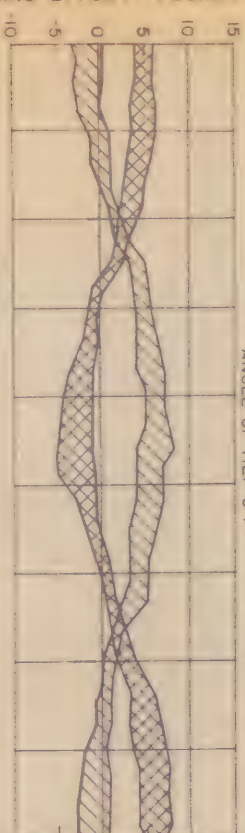
# MANUAL TRAVERSE TURNING EFFORT T 26 TANK

SLOW SPEED

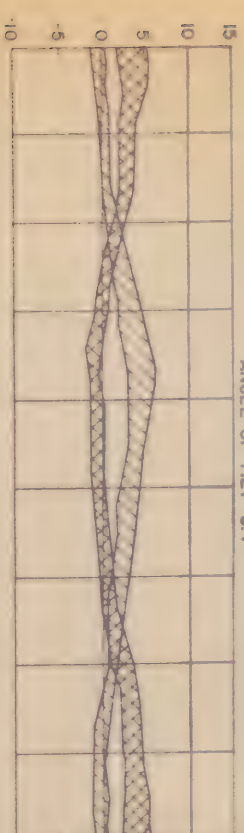
ANGLE OF TILT 11.2° (RIGHT SIDE TANK RAISED)



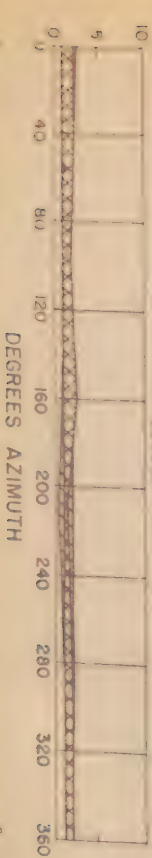
ANGLE OF TILT 6.7°



ANGLE OF TILT 3.4°

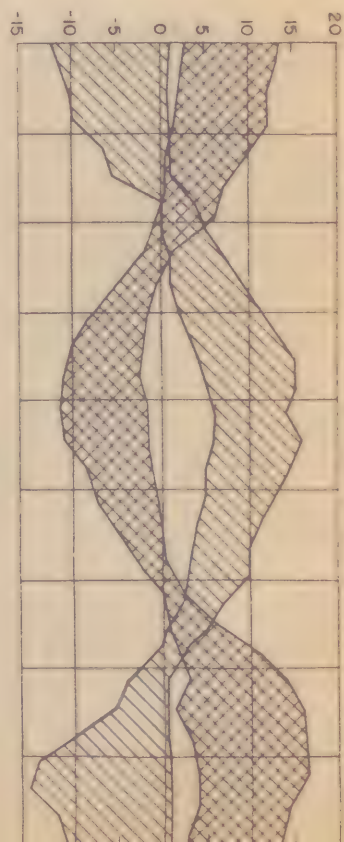


LEVEL

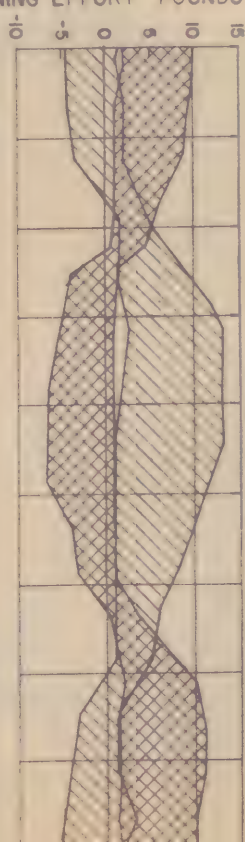


FAST SPEED

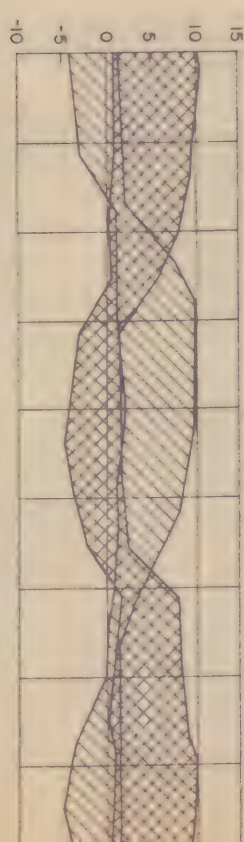
ANGLE OF TILT 11.2°



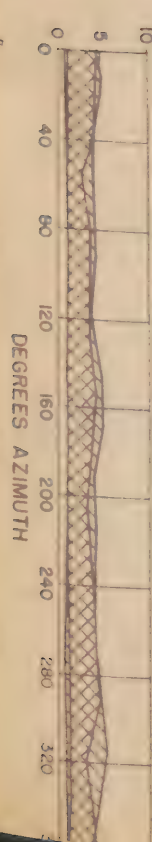
ANGLE OF TILT 6.7°



ANGLE OF TILT 3.4°



LEVEL



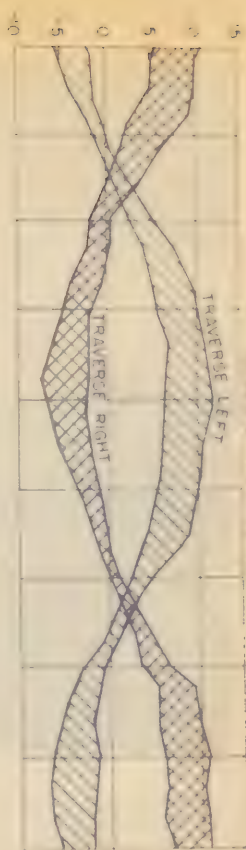




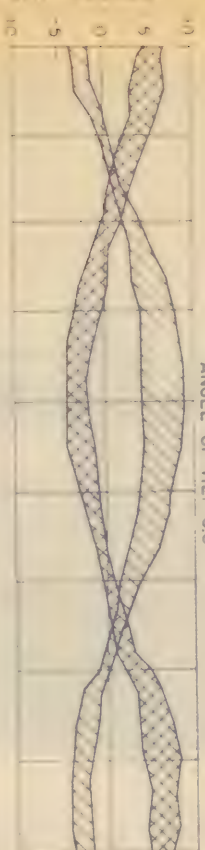
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SLOW SPEED

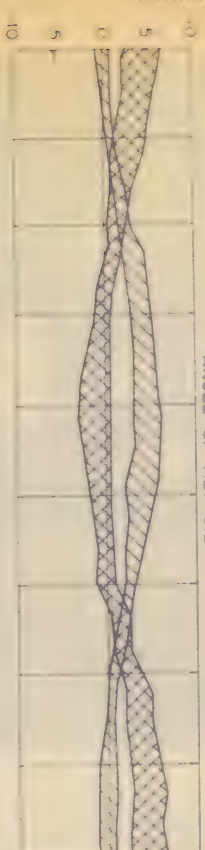
ANGLE OF TILT 9.5° (RIGHT SIDE TANK RAISED)



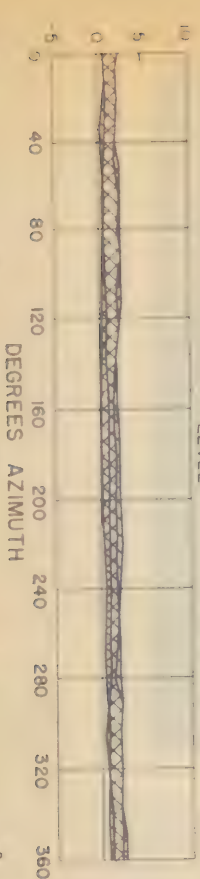
ANGLE OF TILT 6.3°



ANGLE OF TILT 3.2°

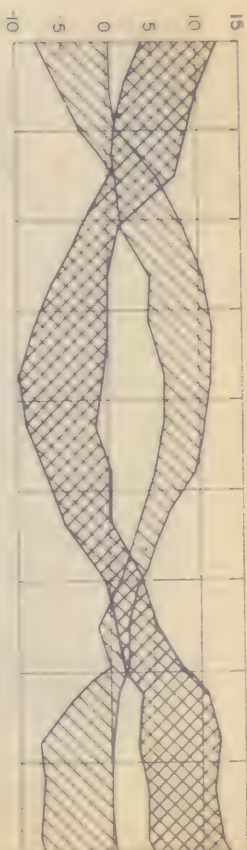


LEVEL

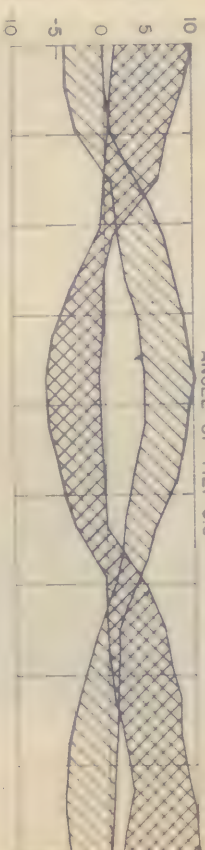


FAST SPEED

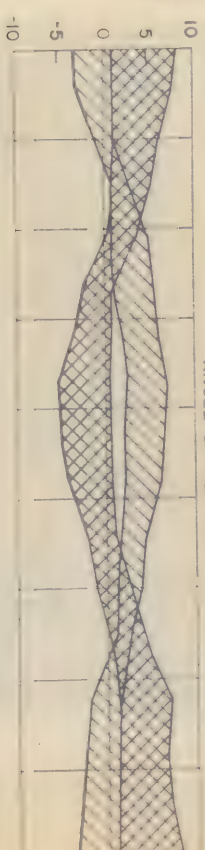
ANGLE OF TILT 9.5°



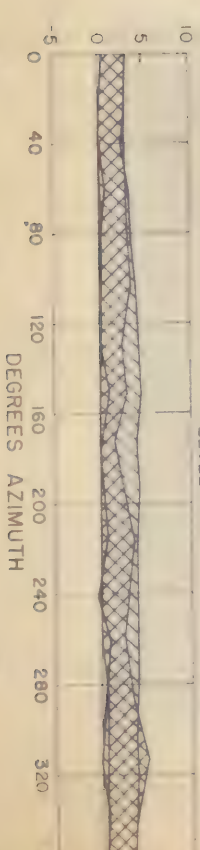
ANGLE OF TILT 6.3°



ANGLE OF TILT 3.2°



LEVEL



TURNING EFFORT - POUNDS

DEGREES AZIMUTH

DEGREES AZIMUTH

FIGURE 8







Figure 9



Figure 10







Figure 11



Figure 12







Figure 13



Figure 14





Figure 15







Figure 16



Figure 17





# SCHEMATIC WIRING DIAGRAM TURRET TRAVERSE EFFORT RECORDER

